SAFETY DISTANCE AWARENESS SYSTEM FOR MALAYSIAN DRIVER

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ABSTRACT

It is known that the risk of an accident increases exponentially with the speed of the vehicle and most collisions happen when the driver fails to brake at the required time and distance. The objective of this research is to create a Safety Distance Awareness System which aims at warning the driver of the potential frontal collision and to alter Malaysian driver attitudes. This system is to manipulate Malaysian driver attitude that likes to tailgating and to prevent rear-end collision in Malaysia. This is done by using a Sound Navigation and Ranging (SONAR) range finder to determine the distance of the vehicle or obstacle in front of the host vehicle. With the help of microcontroller, the distance of the host vehicle could be determined and a warning will be issued in the form of both visual and hearing so driver could take the correct preventive measure. There will be few stages of warning, the system will intensify the distress warning until the collision occurs. These SDAs do not take any automatic prevention or control to the vehicle to avoid collision. In overall the research hopes to achieve a more convenient driving experience and a safer driving environment by implementing the SDAS to keep drivers aware of the potential hazards ahead of their vehicle. Hopefully the Malaysian government will involve in this research, since the implementation of Safety Distance Awareness System can provide a new alternative in the safety system hence it can reduce accidents in Malaysia.

ABSTRAK

Risiko kemalangan meningkat secara langsung dengan kelajuan kenderaan dan kemalangan biasanya berlaku apabila pemandu gagal berhenti pada jarak yang tepat. Tujuan kajian ini adalah untuk mencipta satu sistem pencegahan perlanggaaran bahagian depan kenderaan dengan memberi amaran kepada pemandu dan bertujuan untuk mengubah sikap pemandu di Malaysia. Sistem ini adalah untuk memanipulasi sikap pemandu Malaysia yang suka memandu pada jarak dekat dengan kenderaan hadapan dan untuk mencegah kemalangan dari belakang di Malaysia. Kajian ini menggunakan konsep bunyi ultrasonik untuk menetukan jarak kenderaan. Dengan bantuan mikropengawal, jarak kenderaan pengguna dan kenderaan lain boleh ditentukan dan amaran akan dikeluarkan dalam bentuk visual dan audio supaya pemandu boleh mengambil langkah pencegahan yang sepatutnya. Sistem ini mempunyai beberapa tahap amaran sekiranya pemandu gagal mengikuti amaran pertama, sistem akan meningkatkan tahap amaran. Sistem ini tidak mempunyai pencegahan automatik atau kawalan kenderaan untuk mengelakkan perlanggaran. Secara keseluruhannya, kajian ini bertujuan untuk memberikan pengalaman memandu yang lebih selesa dan persekitaran pemanduan yang lebih selamat dengan menerapkan sistem ini ke dalam kenderaan pengguna. Semoga kerajaan Malaysia akan terlibat dalam kajian ini, kerana ia boleh memberikan alternatif baru dalam sistem keselamatan dan sekaligus mengurangkan kadar kemalangan di Malaysia.

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LIST OF SYMBOLS AND ABBREVIATIONS

SDA	-	Safety Distance Awareness
ADAS	-	Advanced Driver Assistance Systems
ABS	-	Anti-lock Brake System
ESP	-	Electronic Stability Program
BA	-	Brake Assistant
ACC	-	Autonomous Cruise Control
CPU	-	Central Processing Unit
FMCW	-	Frequency Modulated Continuous Wave
AICC	-	Autonomous Intelligent Cruise Control
HMI	-	Human Machine Interface
LED	-	Light Emitting Diode
LCD	-	Liquid Crystal Display
R&D	-	Research and Development
cm	-	Centimeters
km	-	Kilometer
km/h	-	Kilometer per hour
d	-	Distance

g	-	Acceleration due to gravity
G	-	Roadway grade
v	-	Initial vehicle speed
f	-	Coefficient of friction between the tires and the roadway
u	-	Initial velocity
a	-	Acceleration
m	-	Mass
KE	-	Kinetic energy
W	-	Work
F	-	Force
θ	-	Angle
PE	-	Potential energy
PIC	-	Programmable Interface Controller
RAM	-	Random Access Memory
EEPROM	-	Electrically Eraseable Programmable Read-Only Memory
FIS	-	Fuzzy Inference System
ADC	-	Analogue to Digital Conversion
V	-	Voltage
A	-	Ampere
USB	-	Universal Serial Bus
UART	-	Universal Asynchronous Receiver/Transmitter
MCU	-	Multipoint Control Unit
T_{ACQ}	-	Acquicision time
T_{AMP}	-	Amplifier settling time
T_C	-	Holding capacitor charging time

T_{COFF}	-	Temperature coefficient
V_{REF}	-	Reference voltage
d_s	-	Total stopping distance
d_r	-	Reaction distance
d_b	-	Braking distance
t_r	-	Reaction time
PC	-	Personal Computer
AC	-	Alternating current
RF	-	Radio Frequency

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will discuss about the introduction of this research, which includes the research background and the problem statements. The aims and objectives of this research will be discussed too as well as the research scopes.

1.1 Research Background

Nowadays, car plays an important role in daily life because it is a part of a method to reach each person's destination. As a result, the number of cars on the road is increasing. This is significantly increasing the risk of accident. Nearly 70% of highway traffic accidents are caused by not keeping safety distance between moving cars. The driver incorrect judgment for safety distance is the main reason to cause traffic accidents.

In recent years, every country had been studied on automobile anti-collision technology to ensure the driving safety. The statistics show that it will reduce 45% collision if the drivers have more half a second reaction time at the time of the dangerous situation [1]. As a result the modern cars have been equipped with all kinds of measuring and alarm system in order to keep driving safety. The aim of the intelligent equipment is to avoid the car collision and it will become more and more important as a major part in car innovations. Vehicle safety technology is second only to fuel efficiency on customers purchase consideration lists, according to a recent study by RDA Group Global Market Research of Bloomfield Hills, Mich [2].
According to the research, among consumers' top desires for safety features are

collision warning and prevention, greater traction controls, entrapment prevention, and vehicle-to-vehicle communications. Jim Thomas, senior vice president, RDA, said that over the past several years they have seen drivers' attitudes change regarding safety technology.

Vehicle accidents are the major cause of injuries and death in Malaysia. By referring to the road accident statistic in the year 2011 [3] from figure 1.1 below, we can notice that rear-end collisions are the most common accident types. It is very important to keep a safety distance in order to reduce the collision.

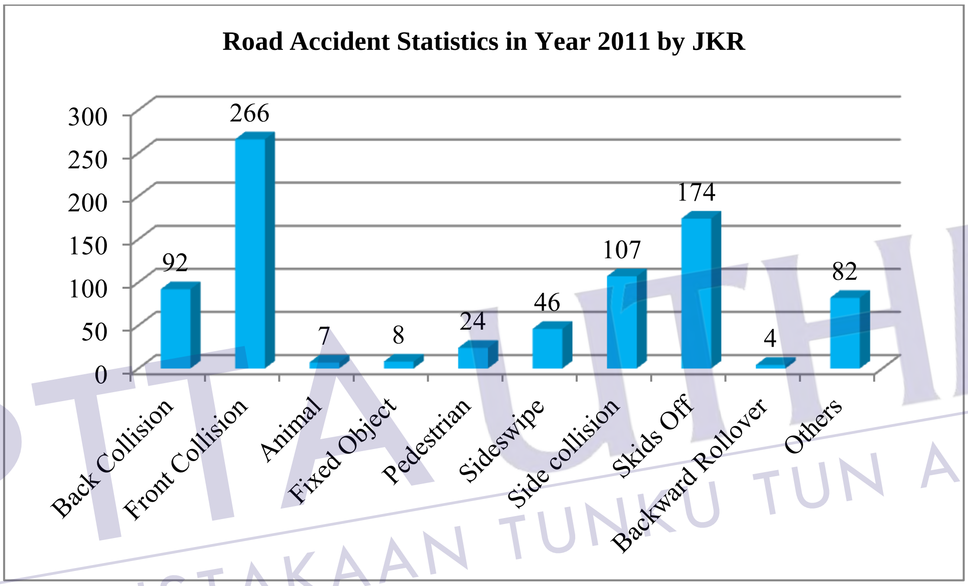


Figure 1.1: Accident statistics based on the type of collision [3]

Safety Distance Awareness (SDA) system targeting for Malaysian drivers who custom to tailgating. This system will psychology alter driver attitude to maintain safety driving distance. It also gives the alarm to give hints and assist the driver to pay attention while driving to avoid dangerous conditions. This system does not have automatic emergency brake, it is still drivers responsibility to observe the traffic and to react in a critical situation.

The SDA system uses ultrasonic sensor, LV-MaxSonar-EZ1 to detect the distance and it will be placed on the front bumper meanwhile microcontroller PIC18F4550 are used to measure the safety distance of a moving car. As an output, LEDs, LCD and buzzer connect to the car's dashboard. Three colors of LEDs are a sign of distance between driving cars, from green for safe distance, yellow for warning distance and red for danger distance. The buzzer will switch on when distance in dangerous situations and the LCD will display the distance and speed of the car. Figure 1.2 demonstrates how the system operates. The method of safe driving distance may not only reduce the traffic accidents but also improved the car's safety.

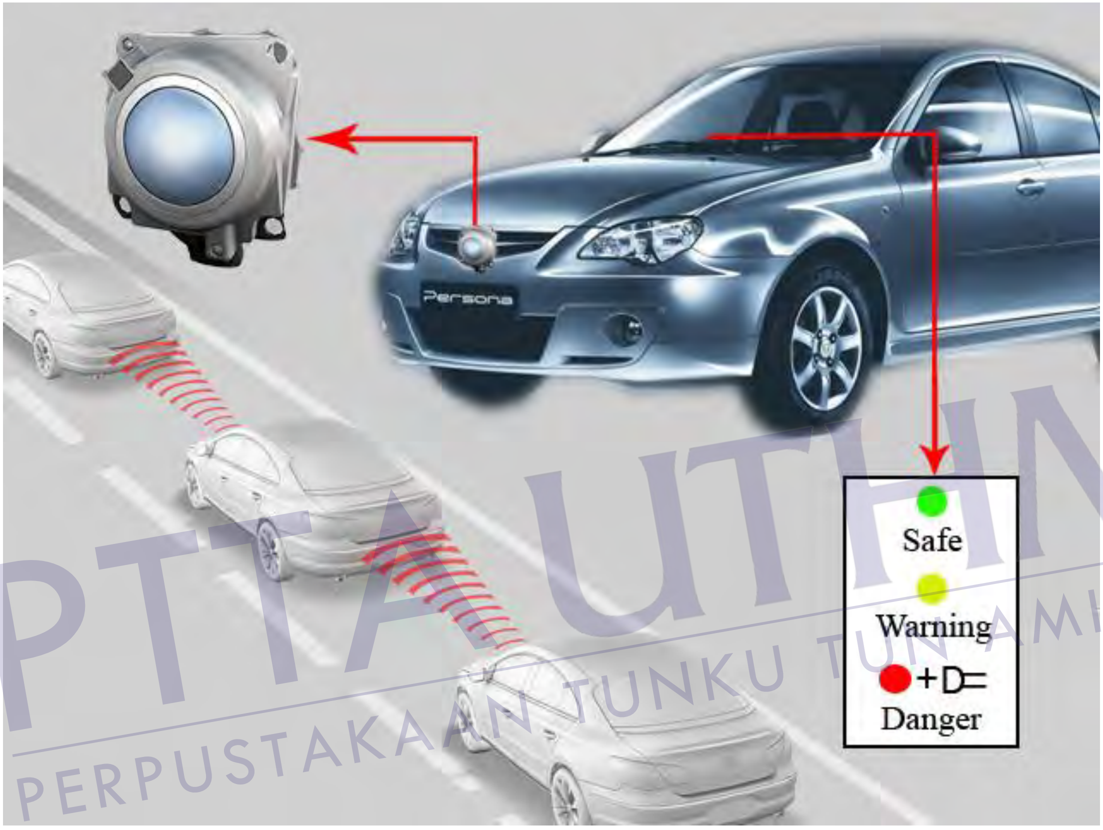


Figure 1.2: System operation

This system can be applied in every vehicle in Malaysia with minimum cost because the current system is too expensive and typically installed in the luxury car only. As a prototype, this system applied to a car prototype and used centimeter (*cm*) unit used for the distance range in the design of the vehicle safety distance calculation.

1.2 Problem Statements

Road traffic injuries will result in the death of about 1.2 million people each year around the world and road traffic accident has become an increasingly serious social problem [4]. Rear-end collisions are responsible for a large amount of crashes, normally occurring at speed up to 30 km/h in city traffic. Following too close is the most common cause of traffic accidents

In the phase of non-free flow, drivers always do not want to lag behind the preceding vehicle and follow it closely. Considering safety, the following vehicle's distance could not be too close to the front. Otherwise, a collision will occur. If there is an enough safe distance between two cars, the driver of the following vehicle will have enough time to respond of the front car changes and implement the emergency measures when the vehicle ahead is suddenly braked. Another factor is the failure of drivers to maintain a safe distance and not keeping braking distance between moving cars, especially when the road is slippery. Besides that, the driver incorrect judgment for braking safety distance because they cannot estimate the suitable distance between their cars from the front car. Due to these factors, they could not be able to take immediate action. Figure 1.3 shows the one impact of bumper to bumper accident [5], its happen in Missouri on Missouri Highway, on August 10, 2011.

Figure 1.3: Impact of bumper to bumper accident [5]

Obviously car technology has improved since the first production can, safety and automation is the main trend of future vehicle development. In the future, the safety distance measurement and alarm system will be the basic equipment in vehicles, although not all the vehicles todays are equipped with this system. Only in modern luxury cars provided the warning system because the systems are too expensive. Our focus of this research is to design a new method to ensure the safety and there are low cost and practicality. This system also can psychology alter driver attitude that custom to drive in close range with the front car.

The technology used for range finding in this project is ultrasonic transducer. This technology however is prone to be affected by surrounding conditions such as air temperature. This is because the speed of sound varies with temperature change, sound travels faster in higher temperature and slower at lower temperature [6]. Moreover, the speed of sound will also get changed with variable pressure, although this change is not as great as in the case of temperature change.

The LV-MaxSonar-EZ1 is ultrasonic transducer that used in this project. The range of this particular ultrasonic sensor is maximum at approximately 6 meters, which is comparably very short range if it was to applied into an SDA system. At that range the SDA system is at its best to be applied at speeds below 50 km/h if the system is applied into a real vehicle. Since any speed higher than that the collision is probably unavoidable if the driver relies only on braking instead of avoiding the obstacle. Futhermore, the beam characteristics of this sensor are very narrow, therefore for best performance in an SDA system the sensor should probably be placed in the middle of a vehicle's front end. The use of more than one sensor could possibly increase the effectiveness of the beam patterns too.

1.3 Research Objectives

The major objective of this research is to develop a system that enables car driver to alert on driving distance between cars.

i. To design a new method to ensure the safety, there are low cost and practical that can be applied to all types of vehicle.

   - Create an awareness system for safety driving by using electronics components.

ii. To alter driver attitude in maintaining right distance

   - To psychology manipulate driver's attitude that love to tailgate and assist them to alert on the safety distance by using technology.

iii. To investigate the safety distance between moving cars.

   - Research about the suitable safety distance between moving car that have been studied by another researcher by using fuzzy.

1.4 Research Scopes

This research is primarily concerned about developing an alert system for safety driving distance. The scopes of this research are:

i. This system is targeted for Malaysian driver to manipulate their attitude to be alert when the following distance is too close.

ii. The ultrasonic sensor is used to detect the distance between driving the car and delivered to microcontroller PIC18F4550 as calculating unit.

iii. The analysis is focused on forward movement.

CHAPTER 2

LITERATURE REVIEW

In order to complete this research, several journals that use similar methods are selected as a reference. All the theories behind this research will be mentioned, which includes the braking distance and the two- second rule. The hardware used in this research also discussed in this chapter, such as ultrasonic sensor for the range finder and the microcontroller for computation.

2.1 Technology Developments

Driven by the desire to control a continuously growing traffic density and a higher complexity in traffic control modern information society is in search of new solutions. Passive safety measures played a main role in the past. In the future active systems so-called advanced driver assistance systems (ADAS) will become more and more important as a major part in electronic innovations for vehicles. ADAS will not only boost driving comfort and safety but also traffic flow. Todays there are already active system available for many cars, ABS (anti-lock brake system), ESP (electronic stability program) or BA (brake assistant). ACC (autonomous cruise control) increases driving comfort and will become available for high-volume cars in the near future [7].

Looking into major national and international research activities, points up current three-stage trends in R&D.

i. Comfort functions to simplify driving tasks in monotonous situations, that is ACC

ii. Warning functions to warn the driver in critical situations, that is lane departure warning

iii. Safety function to reduce or avoid crashworthiness, that is emergency braking

The development focuses more and more on the interaction between vehicles and their driving environment. First of all this includes a detection and interpretation of the driving environment by means of several sensor systems. The necessary abstraction layer of the environment is determined by the ADAS application itself, a simple longitudinal control task for ACC needs only distance and speed measurements of the target driving ahead, whereas warning and safety functions in much more complex driving situations have a need for dimensions of potentially dangerous obstacles. Comprehensive and reliable detection of the driving environment in complex situations like traffic jams on highways or inner city areas require much better sensor information like from a stereo vision sensor.

A study by Shi Wei, Wei Yanfang and Li Xingli (2011) shows that according to the idea of car-following model, the Just Noticeable Difference (J.N.D.) was introduced to analyze how the driver perceives the state of the front vehicle through the change of the headway [8]. The quantitative relationships between car-following distance and road roughness, velocity, reaction time, was induced. The range of car-following distance was also discussed. Furthermore, they have explored the theoretical value of safe distance under different road conditions, such as roads with anti-skid surface, asphalt pavement, rain, snow and ice.

The measurement of safe driving distance on the basis of stereo vision is proposed by Hou A-Lin *et al.*, 2011 [9]. A vehicle-mounted binocular vision distance measuring system is fabricated. The camera calibration method based on 2D planar target is used to calculate the internal and external parameters of cameras, establish the matching relation of corresponding points in the left and the right camera around the image. The corresponding mathematical expressions are given out. The calibrated measuring system is applied to detect the actual vehicle safety distance. The experimental results demonstrated that the system could meet basically the needs of safe driving and contribute to estimate the spacing distance between the camera and the target vehicle or pedestrian. It is convenient for the driver to control and avoid the car collision. The measurement method is feasible and could offer better technical support for auto safety auxiliary driving.

Paper from Yuan-Lin Chen and Chong-An Wang (2007) present a novel algorithm for safety braking distance calculating between driving cars [1]. The presented system concept includes a distance obstacle detection and safety distance calculation. The system detects the distance between the car and in front of vehicles and uses the vehicle speed and other parameters to calculate the braking safety distance of the moving car. The system compares the obstacle distance and braking safety distance which are used to determine the moving vehicle's safety distance is enough or not. This paper focuses on the solution algorithm presentation. The experiment results present the algorithm is useful and worth of development. On 2008, Yuan-Lin Chen, Shun-Chung Wang and Chong-An Wang presents a design of vehicle safety distance warning system [10]. This system can measure distance between in front of the vehicle (obstacle) and driving the car and the system can calculate the safety distance of the driving car. And then a novel algorithm is proposed for to calculate the distance between driving cars is enough or not. If the driver doesn't keep the safety braking distance in front of the car (obstacle), it will warn drivers to slow down the speed of the car to avoid a collision accident in the dangerous condition. The results of the experiment also presented to guarantee the function are working.

Ding Shiqing, Song Yandong and Ding Jibin (2010), have discussed and study about vehicle rear-end collision avoidance system [11]. The mathematical model is established to get the critical safe distance between vehicles with different velocity. The ranging sensor measures the distance between the two vehicles, and then the CPU compare it with the critical safe distance. If collision may occur, the system can remind the driver of adopting the right measure by system warning of voice and light.

Paper from Zhang Dabiao, Kang Yueyi and Liu Hongyun (2007), presents a warning system for automobile collision avoidance based on LabVIEW [12]. The procedure is designed by LabVIEW7.0. The system adopts FMCW radar sensor and high-quality data acquisition card. This system can monitor the distance and velocity forward vehicle. According to the run law of vehicle, a simple formula for safety distance is set up. It can give the alarm when collide danger is predicted, and it can assist the driver to brake control, thus some collision accidents will be avoided. It is flexible to design the program, the different signal processing algorithm can be input and the better program can be selected. This paper presents the design method and main test data.

Vehicle following for traffic safety has been an active area of research. During manual driving, most human drivers often use information about the speed and position of the preceding vehicles in order to adjust the position and speed of their vehicles. Zhigang Li and Ai Juan Song (2009) have proposed a design an autonomous intelligent cruise control (AICC) which mimics this human driving behavior [13]. The proposed AICC law uses relative speed, relative acceleration and spacing information from the preceding vehicles in order to choose the proper control action for smooth vehicle following and for maintaining a desired inter vehicle spacing. In this paper, sliding mode control method considering relative acceleration parameter has been introduced for the headway distance control. Meanwhile the linear tracking-differentiator has been designed for tracking the relative velocity signal and estimating the value of relative acceleration. Theoretical analysis and computer simulation prove that sliding mode control based on tracking-differentiator approach can effectively control intelligent vehicle headway distance.

A forward collision warning algorithm which is based on individual driver characteristics and road condition is proposed by Masumi Nakaoka, Pongsathorn Raksincharoensak and Masao Nagai (2008) [14]. The effectiveness of the algorithm is verified by driving simulator experiments which can change the tire-road friction condition easily and has good repeatability for conducting experiments while securing the experimental safety. Then, the parameter study related to the collision warning timing and the validation of the proposed collision warning algorithm was conducted in urban road driving by using the experimental vehicle. Finally, future research issues obtained from naturalistic urban road driving data are described.

In recent years various collision warning systems for rear-end crash situations have been introduced into the market. Their goal is to reduce the number of fatalities and to mitigate collision consequences. The challenge in the design for such functions is to achieve a high effectiveness for both attentive and inattentive drivers. A possible approach could be an adaptation of the human-machine interface (HMI) to driver attentiveness levels. Neli Ovcharova, Dr. Michael Fausten and Prof. Dr. Frank Gauterin (2012) presents a preliminary study of different visual acoustical

HMI concepts performed in a driving simulator [15]. The participants completed two drives with each warning signal. On the first drive they were distracted by a secondary task and in the second one they were in an attentive state. The statistical analysis of the inattentive drivers' data showed a significant reaction time reduction by employing an acoustical speech warning. A visual alert for inattentive subjects did not result in additional reduction. This paper showed that an adaptation of the warning intensity and modalities to the driver's attention can be useful to increase the benefit and the customer acceptance of collision warning systems

2.2 Braking Distance

The braking distance of a car depends on a number of variables. The slope of the roadway, a car will stop more quickly if it is traveling uphill because gravity will help slow the vehicle. The frictional resistance between the road and the tires of the car is also important. A car with new tires on a dry road will be less likely to skid and will stop more quickly than one with worn tires on a wet road. If the slope and frictional resistance are equal, the factor that has more influence on braking distance is the initial speed. The formula used for calculating braking distances shown in equation 2.1 below [16]:

$$d = \frac{v}{\left(2g(f+G)\right)} \tag{2.1}$$

Where:

d is the braking distance (*m*)

g is the acceleration due to gravity ($9.8ms^{-2}$)

G is the roadway grade

v is the initial vehicle speed (ms^{-1})

f is the coefficient of friction between the tires and the roadway (*u*)

A simpler formula used to calculate braking distance can be derived from a general equation of physics. Ignoring friction, and the roadway grade, we will consider a general equation 2.2 on next page [16]:

$$v = u - 2ad \qquad (2.2)$$

Where:

v is the final velocity (ms^{-1})

u is the initial velocity (ms^{-1})

a is the acceleration (ms^{-2})

d is the distance traveled during deceleration(m)

Since *v* will be zero when the car has stopped, the equation can be re-written as equation 2.3 below [16]:

$$d = \frac{u}{2a} \qquad (2.3)$$

The total distance it takes for the car to come to a stop can be found by adding the reaction distance to the braking distance.

As we can see, equation 2.3 involves the use of acceleration [16]. For a more general purpose, let's consider equation 2.4. Kinetic energy is the energy of motion. An object which has motion, whether it is vertical or horizontal motion has kinetic energy. The amount of translational kinetic energy which an object depends upon two variables, the mass (*m*) of the object and the speed (*v*) of the vehicle. The following equation is used to represent the kinetic energy (*KE*) of the vehicle.

$$KE = \frac{1}{2} \times m \times v^2 \qquad (2.4)$$

Where:

m = mass of the object

v = speed of object

On the other hand, when a vehicle brakes, the force of friction acts upon the vehicle and that work is proportional to the stopping distance, as shown in equation 2.5 on the next page [16].

$$W = F \times d \times cos\theta \qquad \textbf{(2.5)}$$

Where:

F = Force

d = Displacement

θ = Angle between force and displacement vector

The angle is equal to 180 degrees because the force of friction and displacement of the vehicle are in opposite directions.

The equation for the work - energy relationship is shown below in equation 2.6 [16]:

$$KE_i + PE_i + W_{ext} = KE_f + PE_f \qquad \textbf{(2.6)}$$

Where:

KE = Kinetic energy

PE = Potential energy

W = work

Since the potential energy of the vehicle is the same for both initial and final states, they can be cancelled the equation. And since the vehicle is finally stopped, the KE_f term would be zero, thus the equation becomes equation 2.7 as shown below [16]:

$$0.5 \times m \times v^2 + F \times d \times cos180° = 0 \qquad \textbf{(2.7)}$$

Since cos(180°) is -1, the equation can be rewritten as equation 2.8 [16]:

$$0.5mv^2 = F \times d$$
$$v^2 \propto d \qquad \textbf{(2.8)}$$

From the above equation depicts the stopping distance (d) is being dependent upon the square of the speed (v^2)

2.3 The Two-Second Rule

The safe and correct following distances are difficult to establish. For this reason, the 2 second rule is used to gain a safe following distance at any speed [17]. The rule is that a driver should ideally stay at least two seconds behind any vehicle that is directly in front of the driver's vehicle. This distance is of course extended for the 2 seconds the faster you travel.

Using the two-second rule helps to significantly reduce accidents or reduce collision damage if one occurs. Using the two-second rule provides not only a general safer way of driving, but can also help to save fuel, brake wear and paint damage as a result of stone chips occurring due to driving too close to the car in-front. The simple and effective two-second rule only applies to dry weather conditions and should be extended depending on the weather. Generally if the conditions are wet, the two seconds should be double to four seconds to allow for longer braking distances due to slippery roads.

The practice has been shown to dramatically reduce risk of collision, and also the severity of an accident should an accident occur. It also helps to avoid tailgating and road rage for all drivers. The risk of tailgating is largely caused by the accident avoidance time being much less than the driver reaction time. The two-second rule isn't just for the car in-front however. If a car is driving too close behind us (tailgating), we will also need to take their thinking distance into account by leaving a sufficient and safe distance between our car and the car in-front. By following the 2 second rule, if the car in-front of us brakes sharply, we will be able to slow down in good time, but also allow plenty of time for the car behind to slow down [18].

To estimate the time, a driver can wait until the rear end of the vehicle in front passes any distinct and fixed point on the roadway such as a road sign, lamp post or tree in the road. Figure 2.1 shows when the two-second rule should start. As the vehicle passes the fixed point, start counting "one thousand and one, one thousand and two" or for greater accuracy, it is suggested that drivers say "only a fool breaks the two-second rule". On a normal speaking rate, this sentence takes approximately two seconds to say, and serves as a reminder to the driver of the importance of the rule itself [17]. However, don't take our eyes off the vehicle for more than a second or that would defeat the purpose. As we count the elapsed time in seconds, the front of our car should pass the same point no less than two seconds later. If the elapsed time is less than this, increase the distance, then repeat the method again until the time is at least 2 seconds. Figure 2.2 show when two-second rule finish.

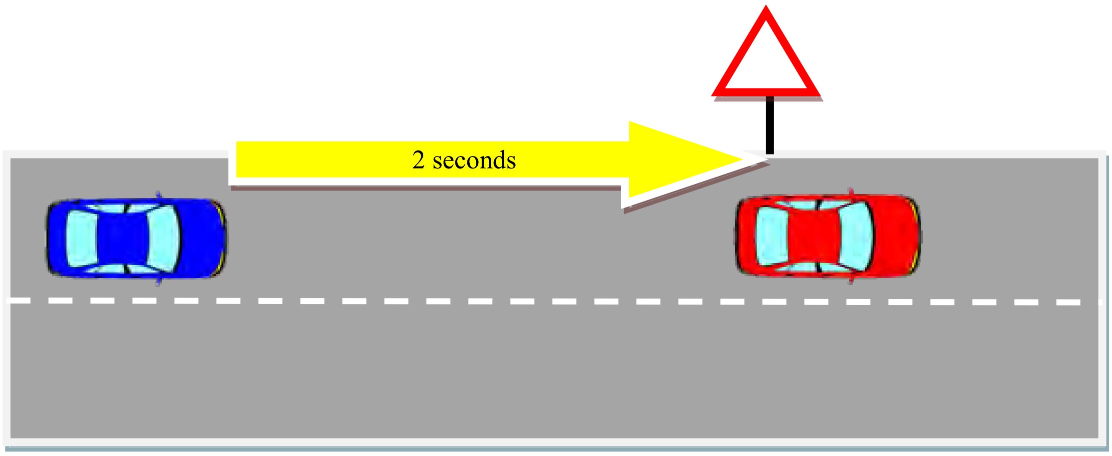


Figure 2.1: Two-second rule starts

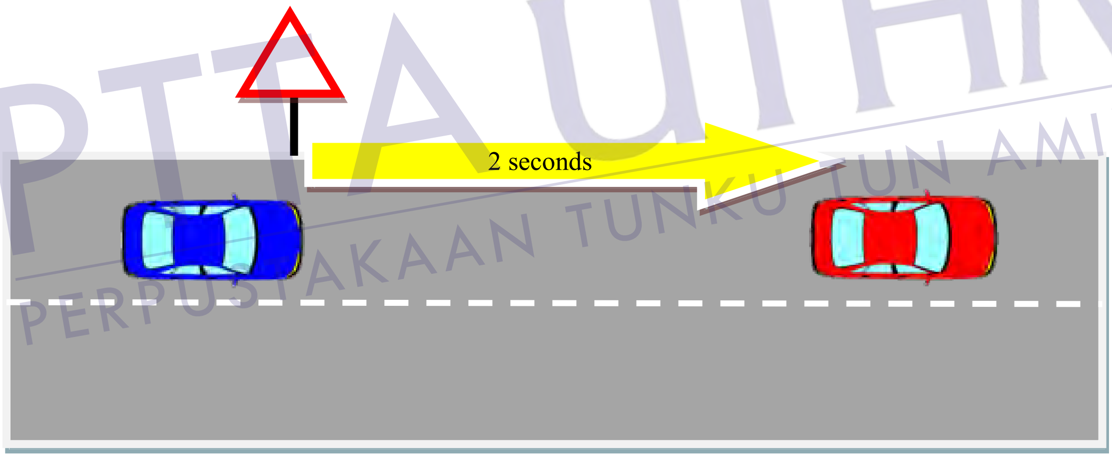


Figure 2.2.: Two-second rule finish

2.4 Sensor

Sensors are sophisticated devices that are frequently used to detect and respond to electrical or optical signals. A Sensor converts the physical parameter such as temperature, blood pressure, humidity, speed, and so on, into a signal which can be measured electrically [19].

There are certain features which have to be considered when we choose a sensor. They are as given below:

i. Accuracy
ii. Environmental condition - usually has limits for temperature/ humidity
iii. Range - Measurement limit of sensor
iv. Calibration - Essential for most of the measuring devices as the reading changes with time
v. Resolution - Smallest increment detected by the sensor
vi. Cost
vii. Repeatability - The reading that varies is repeatedly measured under the same environment

Different classifications of sensors were studied and comparisons were studied and comparisons were made to find a suitable type of sensor for this project. Table 2.1 on the next page shows the comparisons of sensor [20].

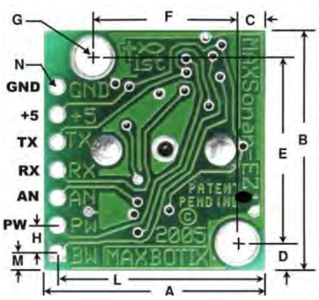
Table 2.1 : Sensor comparison [20]

	Ultrasonic sensor	**Laser sensor**	**Infrared sensor**
Applications	Short range distance detector	Speed laser gun	Remote control, robot
Temperature range	-20°C to 60°C	50°C	0°C to 50°C
Distance range	Less than 10 meters	1 meter – 150 meters	Less than 5 meters
Cost	RM 25 – RM 145	More than RM 1000	Cheap with different type
Advantages	- Suitable in a certain distance - Using the signal that long wavelength - Easy to build and cheap	- Can reach quite long distance - Hard to interrupt with interference - Very sensitive	- Good sense for short distance - Commonly used and easy to get - Easy to build and cheap
Disadvantages	- Short distance - Not very sensitive	- Expensive - Dangerous for human sight - Only direct emit	- Distance not suitable - Easy interrupt

2.4.1 Ultrasonic sensor

Ultrasonic signals are like audible sound waves, except the frequencies are much higher. The ultrasonic transducer has piezoelectric crystals which resonate to a preferred frequency and convert electric energy into acoustic energy and vice versa.

The LV-MaxSonar-EZ1 is a high performance sonar range finder developed by MaxBotic Inc. The LV-MaxSonar-EZ1 offers very short to long-range detection and ranging, in an incredibly small package with ultra low power consumption. The LV-MaxSonar-EZ1 detects objects from 0-inches to 254-inches (6.45-meters) and provides sonar range information from 6-inches out to 254-inches by 1-inch resolution. Objects between 0-inches and 6-inches range as 6-inches. The interface output formats included are pulse width output, analog voltage output, and asynchronous serial digital output [21]. In this project LV-MaxSonar-EZ1 is used as the range finder on the system for measurements of the distance and the product image and dimension of the LV-MaxSonar-EZ1 is shown in Figure 2.3 on the next page.



A	0.785"	19.9 mm	H	0.100"	2.54 mm
B	0.870"	22.1 mm	J	0.610"	15.5 mm
C	0.100"	2.54 mm	K	0.645"	16.4 mm
D	0.100"	2.54 mm	L	0.735"	18.7 mm
E	0.670"	17.0 mm	M	0.065"	1.7 mm
F	0.510"	12.6 mm	N	0.038" dia.	1.0 mm dia.
G	0.124" dia.	3.1 mm dia.	weight, 4.3 grams		

values are nominal

Figure 2.3: LV-MaxSonar-EZ1 product and dimension

2.5 Microcontroller

A microcontroller is a single chip computer, or where *Micro* clearly stands for small and *controller* tells you that the device might be used to control objects, processes, or events. Another term to describe a microcontroller is embedded controller, because the microcontroller and its support circuits are often built into the devices they control [22].

Microcontrollers are widely used in a device that measures, stores, controls, calculates and displays information. One of the largest single use of microcontrollers would be in automobiles industries, where it is used for the engine control unit (ECU) and other additional systems in an automobile. In computers, microcontroller can be found inside keyboards, modems, printers, and other peripherals. In test equipment, microcontrollers make it easy to add features such as the ability to store measurements, to create and store user routines, and to display messages and waveforms. Consumer products that use microcontrollers include cameras, video recorders, compact-disk players, and ovens.

A microcontroller differ from a microprocessor. Microprocessor is a multipurpose, programmable, register based electronic device which reads binary instructions from memory, processes the input data as per instructions and provides output. While microcontroller is a device that includes a microprocessor, memory. Input and output devices on a single chip. Table 2.2 shows the comparison between microcontroller and microprocessor [23].

Table 2.2 : Comparison between microcontroller and microprocessor [23]

Microcontroller	Microprocessor
Microcontroller having inbuilt RAM or ROM and inbuilt timer	Do not have inbuilt RAM or ROM and timer
Input and output ports are available	Input and output ports are not available, requires an extra device like 8155
Inbuilt serial port	Do not have inbuilt serial port, requires 8250 devices
Separate memory to store program and data	Program and data are stored in the same memory
Many functions pins on the IC	Less multifunction pins of IC
Boolean operation directly possible	Boolean operation is not possible directly
It takes a few instructions to read and write data from external memory	It takes many instructions to read and write data from external memory

The Programmable Interface Controller or PIC is a family of microcontrollers develop by Microchip Technology featuring the Harvard architecture. PIC microcontrollers are widely used for industrial purpose due to its high performance ability at low power consumption. It is also very famous among hobbyists due to moderate cost and easy availability of its supporting software and hardware tools like compilers, simulators, debuggers and so on [24]. The PIC used in this project is the PIC18F4550, which is an 8-bit machine to operating speed up to 48 MHz. It has 32K of FLASH memory for programs and 2048 bytes of RAM. There are 256 bytes of EEPROM for data saving too [25].

2.6 Fuzzy Inference System

A Fuzzy Inference System (FIS) is a way of mapping an input space to an output space using fuzzy logic. A FIS tries to formalize the reasoning process of human language by means of fuzzy logic. This is mainly based on the concepts of the fuzzy set theory, fuzzy IF-THEN rules, and fuzzy reasoning. FIS uses "IF… THEN…" statements, and the connectors present in the rule statements are "OR" and "AND" to make the necessary decision rules [26]. FIS is used to solve decision problems, that is to make a decision and act accordingly.

2.6.1 Structure of a fuzzy inference system

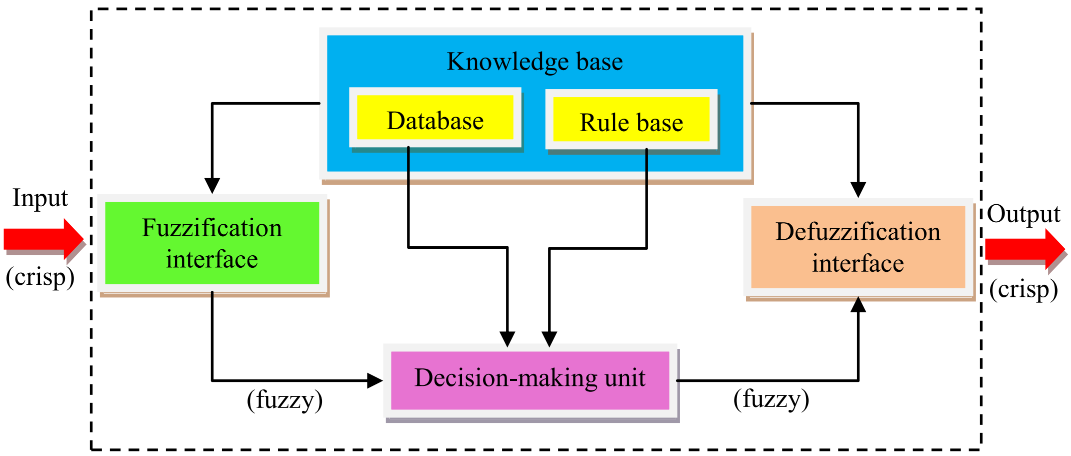


Figure 2.4: FIS block diagram

A FIS with five functional block diagram described in Figure 2.4. The function of each block is as follows:

i. a rule base containing a number of fuzzy IF-THEN rules
ii. a database which defines the membership functions of the fuzzy sets used in the fuzzy rules
iii. a decision-making unit which performs the inference operations on the rules
iv. a fuzzification interface which transforms the crisp inputs into degrees of match with linguistic value
v. a deffuzification interface transforms the fuzzy results of the inference into a crisp output

The working of FIS is as follows. The crisp input is converted into fuzzy by using fuzzification method. After fuzzification the rule based is formed. The rule based and the database is jointly referred to as the knowledge base. Deffuzification is used to convert the fuzzy value to the real world which is the output.

Fuzzy Inference Systems used to solve the decision problem in this system because of the following reasons:

i. Fuzzy logic does not solve new problems. It uses new methods to solve everyday problems.
ii. Mathematical concepts within fuzzy reasoning are very simple.
iii. Fuzzy logic is flexible: it is easy to modify a FIS just by adding or deleting rules. There is no need to create a new FIS from scratch.
iv. Fuzzy logic allows imprecise data it handles elements in a fuzzy set
v. Fuzzy logic is built on top of the knowledge of experts: it relies on the know-how of the ones who understand the system.
vi. Fuzzy logic can be blended with other classical control techniques.

CHAPTER 3

METHODOLOGY

This chapter will describe the methods that used in this research**.** This research implementation will divide into three parts in order to make everything more systematic, manageable and easier to troubleshoot. First is the research flow will be discussed. Second is the system configuration for this system. Third safety distance measurement flow charts for vehicle safety distance calculation between driving a car and front of a moving car. Gantt chart also one of the important things to make sure to manage this research properly and it's simple to understand and easy to construct. Gantt charts are a research planning tool that can be used to represent the timing of tasks required to complete a research. Gantt chart of this research will attach at the appendix.

3.1 Research Flow

There are five stages that involve in methodology that shows in figure 3.1 on the next page. The first stage of the research involved mainly of literature reviews. At research stage, all the information and the problem and the other thing that associated with the main problem are identified. The important points has been figured out through some studies. Then the objective and scope of the research were identified to get suitable components and software needed. After reviewing through the articles and information regarding safety distance awareness system, it was decided that the ultrasonic sensor to be used is MaxSonar EZ1 for range finding and PIC18F4550 for all the digital conversion and programming.

At the second stage, combined all the information from the first stage. This phase is done to verify the requirement of the research, limitation and the time required to complete the research.

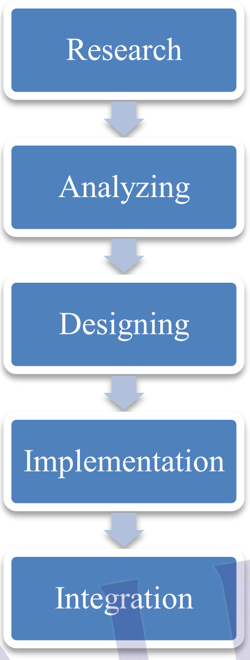


Figure 3.1: Block diagram of Methodology

The next stage involves circuit construction for the sensor and microcontroller. The circuit design was simulated using Proteus software. For writing and implementation of assembly language MPLab software was used.

Trials on the circuitry connections are carried out on tester board on implementation stage. Sensor circuit was connected to microcontroller circuit that designed to send the input to the PIC, then LCD, LEDs and buzzer as an output.

Finally in the last stage, the hardware will go through some troubleshooting to identify the efficiency. Any failure will be solved by adjusting the circuit and coding until the system working at maximum capacity. The test is done both on the hardware design and software simulation. Debugging is done to improve the system. Both the software and hardware were implemented to make sure everything is running smoothly into one complete system.

3.1.1 Design Flow

Based on the requirement, the design is divided into two developments, which is software development and hardware development. In order to confirm the system is working, the programming and circuit design needs to be done correctly. Figure 3.2 below shows the design flow of this research and figure 3.3 is the overall research planning flow chart.

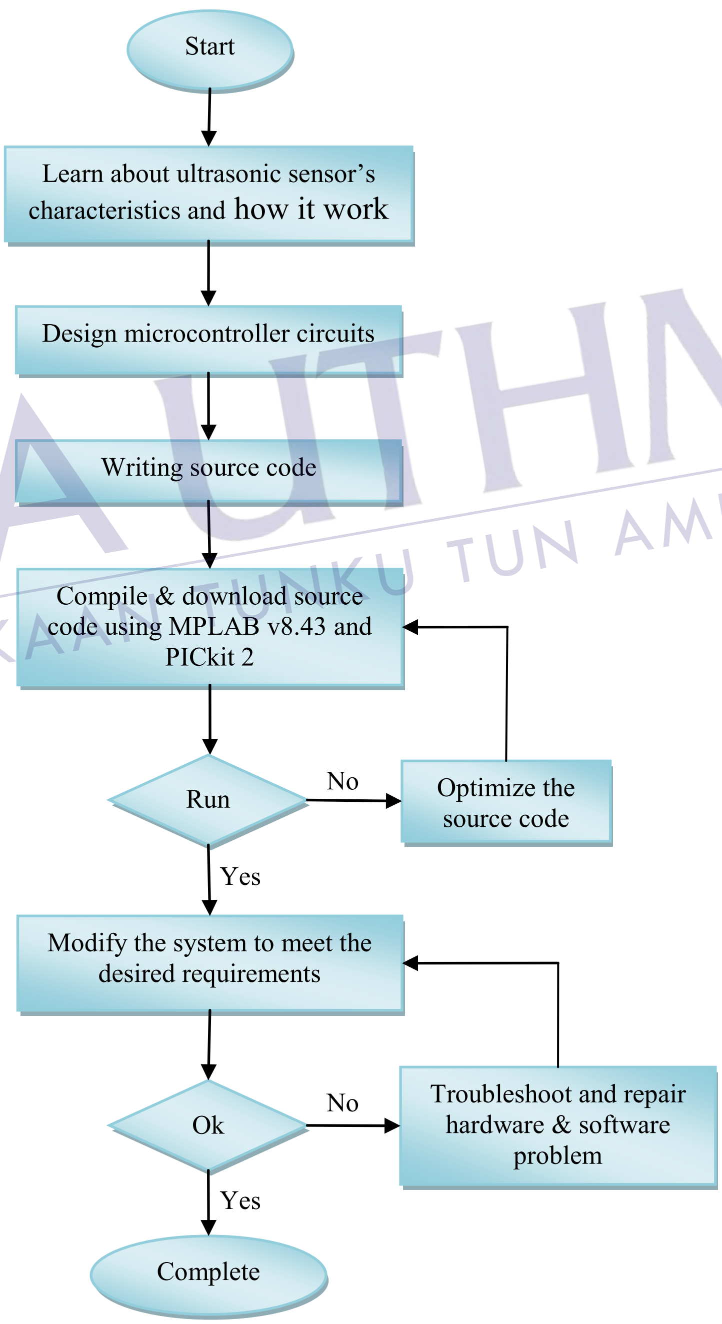


Figure 3.2: Design flow

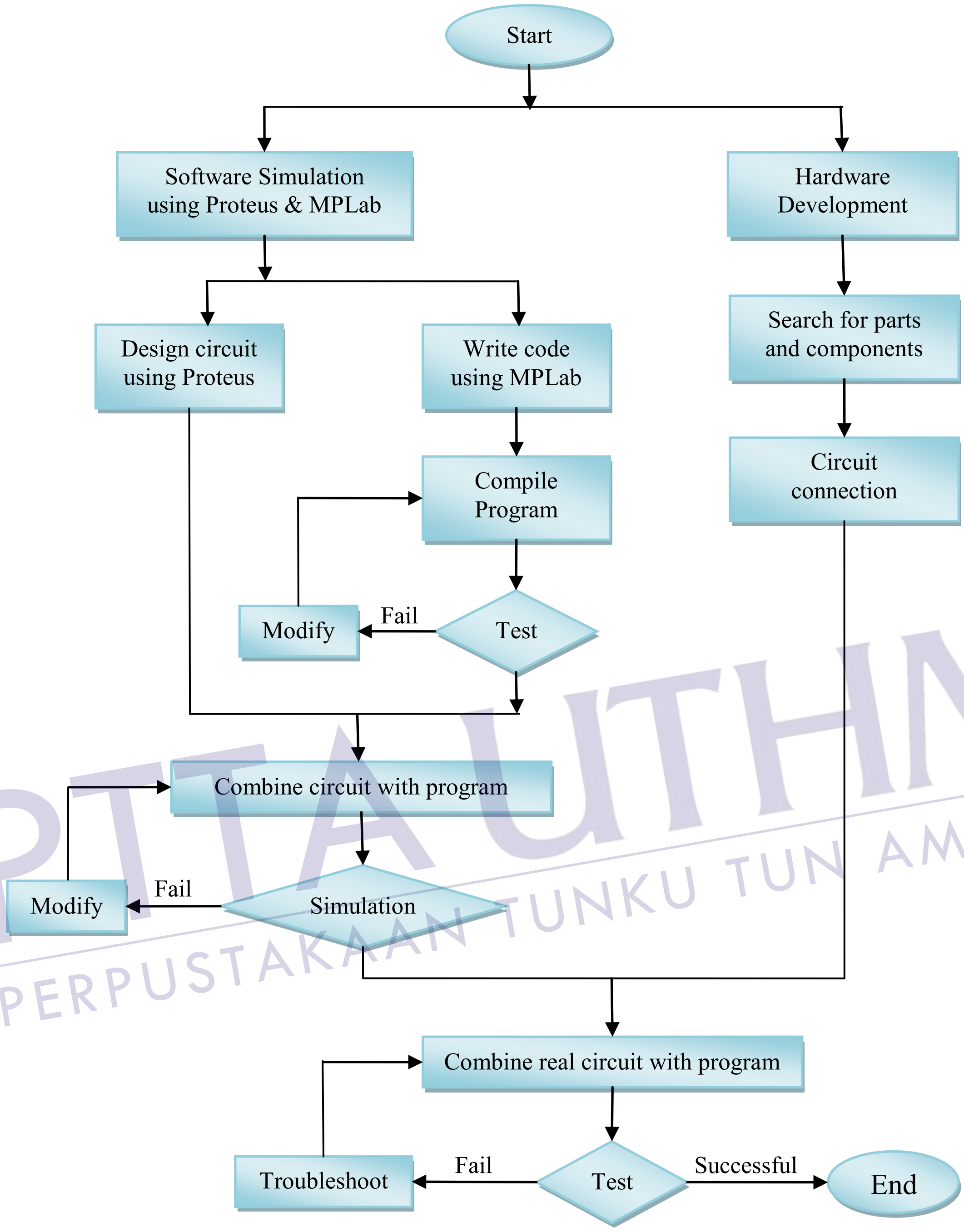


Figure 3.3: Overall research planning flow chart

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